*Yucatec Maya Vowel Alternations – Harmony as Syntagmatic Identity**

Martin Krämer

Heinrich-Heine-Universität Düsseldorf

kraemer@phil-fak.uni-duesseldorf.de

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Abstract

In this paper, I will give a detailed account of vowel harmony, disharmony, dissimilation, and elision in Yucatec Maya. These phenomena provide insights for the treatment of assimilation in Optimality Theory (Prince & Smolensky 1993). The theoretical topics to be dealt with are (i) an adequate formalisation of phonological feature assimilation within Correspondence Theory (McCarthy & Prince 1995), and (ii) an account of morpheme-specific alternations within this framework. I will argue that harmony, or assimilation in general, surfaces due to a Faithfulness constraint family, 'Syntagmatic Identity', which establishes a correspondence relation between segmental or prosodic entities of the same type within one representation.

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1 Introduction

Yucatec Maya vowel harmony and vowel dissimilation are a typical example of a morpheme-specific phonological feature alternation. Some affixes in Yucatec Maya copy the preceding root vowel, while other suffixes retain their underlying feature profile. Moreover, the harmony process is blocked in a rather interesting context – when more than one consonant is placed between the suffix vowel and the root vowel. In this environment, the suffix vowel has always the quality *a*. The situation is even more compelling since the Yucatec Maya morpheme inventory also contains an affix with a vowel which surfaces with the opposite backness value than that of the root vowel. A fourth type of affix dissimilates in the dimension of vowel height. Such contradictory phenomena might be taken as evidence for rule and level based phonological theories, where dissimilation is assumed active on an early level, while vowel harmony is active on a second level of derivation, and disharmonic affixes are assumed to be added on an even later level. This characteristic makes these phenomena a challenge for

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a parallelist theory like Optimality Theory (Prince & Smolensky 1993), in which no intermediate levels or stages between the input and the output of a derivation are assumed.
The questions to be answered in this paper concerning the Yucatec data are: i. How can morpheme-specific alternations be accounted for in a theory which denies the existence of derivational levels? ii. How can harmony and dissimilation both be explained adequately in such a theory? iii. What is it exactly that blocks the application of harmony in Yucatec?
In this paper, two major goals will be pursued: I will introduce a unified theory of assimilation and dissimilation within correspondence theory (McCarthy & Prince 1995). Furthermore, I will give an appropriate account of the Yucatec data within this theory. Assimilation is best analysed as a correspondence relation between segments or prosodic categories like moras or syllables within one representational string, i.e. the surface representation. This correspondence relation will be labelled 'Syntagmatic Identity'.
The paper is structured as follows. In section 2, the basic assumptions of the proposal to treat assimilation as a correspondence relation will be developed. In section 3, Yucatec Maya vowel alternation patterns will be introduced and it will be shown that the moraicity of coda consonants plays a crucial role in the analysis of harmony blocking (section 3.2). Harmony and blocking will be examined in detail in sections 3.1 to 3.3, while section 3.4 explores the possibility of underparsing (i.e. vowel elision) as a strategy to escape violation of the constraints which demand harmony. Section 3.5 is concerned with vocalic dissimilation and extends the analysis of Yucatec Maya harmony developed in sections 3.1, 3.2, and 3.3 to dissimilation patterns. Section 4 compares the correspondence approach of harmony with other approaches within OT. Section 5 summarises and concludes the discussion.

2 Basic assumptions

The basic assumptions of Optimality Theory will be taken for granted in this paper. For an introduction to the theoretical architecture the reader may consult Prince & Smolensky (1993), McCarthy & Prince (1995), Archangeli & Langendoen (1997), or Kager (1999). In this section, I will concentrate on introducing my proposal on how to deal with assimilation within this framework.

2.1 The formalisation of assimilation

What happens in harmony or any kind of assimilation is intuitively the same as what is encoded in one of the basic faithfulness constraint families of OT: IDENTITY(feature) says that segments in one representation (usually the input) should agree in feature specifications with the respective segments in another representation (usually the output), i.e. they should look alike:

(1) The IDENT(F) Constraint Family McCarthy & Prince (1995:264)
Let α be a segment in S_1 and β be any correspondent of α in S_2.
If α is [γF] then β is [γF].
(Correspondent segments are identical in feature F.)

Input-output correspondence and surface or syntagmatic correspondence differ in the dimensions of the respective correspondence relation. In IO-faithfulness relations, the corresponding elements are in different representations. In contrast, syntagmatic correspondence relations hold between two distinct elements within one representation, i.e. the output. Another difference is the functional motivation of the types of correspondence. IO-faithfulness constraints optimise the accurate interpretation of an utterance, while assimilatory correspondence optimises articulation. That is, IO-faithfulness is driven by the desire of the speaker to be understood, whereas assimilation is driven by the speaker's wish to minimise the articulatory effort. A further motivation for the latter correspondence relation may be the optimisation of utterance chunking. Harmony domains help the hearer to reconstruct an utterance into words.[1] In this respect, both kinds of correspondence share a function: optimisation of interpretation.

Pulleyblank (1997) proposes to analyse consonantal assimilation as an effect of Syntagmatic Constraints, as opposed to Input-Output constraints.[2] Lombardi (1999:272 and earlier papers) and Gnanadesikan (1997) present similar constraints to handle laryngeal assimilation (Lombardi assuming privative voice, Gnanadesikan a ternary voicing scale).

(2) Pulleyblank (1997:64): IDENTICAL CLUSTER CONSTRAINTS:
A sequence of consonants must be identical in *voicing / place of articulation / continuancy / nasality*.

(3) Lombardi (1999:272): AGREE: Obstruent clusters should agree in voicing.

(4) Gnanadesikan (1997:23): ASSIM: The output {scale} value of adjacent segments must be identical.

Such constraints can be incorporated into the correspondence constraint family. The first task is to define the correspondence relation as a relation between distinct elements of the same type within one representation instead of referring to two representations. By this move, the core statement of the above-mentioned assimilation constraints can be formulated more generally, resulting in a uniform formalism for feature assimilation in general, covering vocalic as well as consonantal assimilation, as I propose in(5).

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1 In a series of experiments on speech segmentation, Vroomen, Tuomainen & de Gelder (1998) found that Finnish listeners use word stress as well as vowel harmony (i.e., instances of changes from back to non-back spans) as cues to determine word boundaries.

2 An interesting point here is that even though Pulleyblank (1997) proposes Identical Cluster Constraints (ICC), i.e. something very similar to Faithfulness constraints, to handle consonantal assimilation, he formalises assimilation between vowels as featural Alignment. (See section 4 for a discussion of the Alignment approach to vowel harmony.)

(5) SYNTAGMATIC IDENTITY(F) (S-IDENT, preliminary schema):[3]
Let x be a segment in representation R and y be any adjacent segment in representation R, if x is [αF] then y is [αF].
(A segment has to have the same value for a feature F as the adjacent segment in the string.)

Under the assumption of flat segmental structure, i.e., CVCVC, such a constraint would rule out any kind of vowel harmony, since between each vowel there is a consonant. Two solutions are possible: Either vocalic features are coproduced on consonants, while consonantal features cannot be coproduced on vowels (as proposed by Ní Chiosáin & Padgett 1997), or the 'segment' referred to in the definition of the constraint is only one possible variable of Syntagmatic Identity. This means that the interaction of vocalic features or nasality for example takes place on other categories than the segment, specifically moras, syllables, or feet. In the following, I will explore the latter possibility, drawing on and extending a proposal made in Grounded Phonology (Archangeli & Pulleyblank 1994). Arguments against the Ní Chiosáin & Padgett (1997) coproduction account will be given in sections 3.2 and 4.
In the literature, it is often assumed that vocalic assimilation processes apply from mora to mora or syllable head to syllable head (see e.g. Archangeli & Pulleyblank 1994 or the discussion in van der Hulst & van de Weijer 1995). According to Archangeli & Pulleyblank (1994), Piggott (1996) and others, different features are associated with different prosodic entities or tiers. Piggott (1996) argued that in Lamba, nasal harmony applies from syllable to syllable, while in Kikongo, it goes from foot to foot. Piggott (1996:150) gives the following typology of harmony(6).

(6) A typology of harmony
a. Segment harmony (= segment-to-segment relation)
b. Syllable harmony (= syllable-to-syllable relation)
c. Foot harmony (= foot-to-foot relation)

Archangeli & Pulleyblank (1994) propose segments, moras and syllables or syllable heads as anchors for features, ignoring the foot.
To capture harmony formally, Piggott assumes the constituent concord constraints given in(7).

(7) Constituent Concord Right/Left (CONCORD-R/L) (Piggott 1996:150)
If constituent α is specified for Nasal in an input, then constituent β to the right/left of the correspondent of α in an output is also specified for Nasal, if α and β are in the same domain.

The problem with this definition is that it is asymmetric in two ways: (i.) we have a right/left parametrisation as is the case with the Alignment approach as well (see section 4.1). (ii.) what

[3] In Krämer (1998, 1999), Syntagmatic Identity was labelled 'Surface Identity'. This was ambiguous since Output-Output Correspondence is also a kind of 'surface' relation, though a paradigmatic one. The term 'Syntagmatic Identity' is more appropriate and less confusing, I hope.

is described here is a harmonic relation between an input and the element following this in an output. Technically the possibility arises that in a string of underlying nasal-vowel-liquid sequences, e.g. NVR_1VR_2V, the initial nasal N triggers assimilation of the following liquid R_1, but the second liquid R_2 remains unnasalised, even though it is in the same harmonic domain in the output. This is because the constituent concord ConCord-R holds only with the underlying specification of its neighbour to the left, not with its surface specification, as illustrated below.

(8) Harmony as Constituent Concord:

Input:	/N	V	R_1	V	R_2	V/
Output:	n	V	n	V	l	V

If this were the right way to analyse harmony, vowel harmonic systems should look like this: In a language with ConCord-R, the first two vowels of a word should look alike with regard to the crucial feature, but the third vowel has to look like the underlying form of its neighbour on the left, potentially resulting in a disharmonic surface form. The same holds for all following vowels. The fact is, however: harmonic languages don't look like this. For this reason, I will prefer the symmetric transitive correspondence relation within surface strings proposed in (5). On the basis of the fact that harmony is also a relation between prosodic categories, Syntagmatic Identity can be reformulated as in(9).

(9) Syntagmatic Identity (S-Ident(F), preliminary schema): [4]
Let x be an entity of type T in representation R and y be any adjacent entity of type T in representation R, if x is [αF] then y is [αF].
Where T is a segment, mora, syllable, or foot.
(A segment, mora, syllable or foot has to have the same value for a feature F as the adjacent segment, mora, syllable or foot in the string.)

An important question concerning the connection of segmental features with prosodic domains is why certain features have access to higher domains while others don't. A preliminary answer may be that only features which are typical for segments with high sonority, i.e., features of segments that can constitute a syllabic peak, can have access to higher prosodic domains. Since this issue is not crucial for the current argumentation, I will leave it with this vague assumption here.

2.2 The domains of constraints

So far, I have been dealing with the formalisation of assimilation as correspondence and with the question between which entities such correspondence relations may hold. Another relevant question touches on the domains in which assimilation processes apply and how this can

[4] In the remainder of this paper, constraints of this kind (Syntagmatic-Identity) will be abbreviated as S-Identσ/μ[feature], where σ or μ indicates whether the particular correspondence relation holds for syllables or moras. Within the square brackets, the feature is given which is affected by the correspondence relation.

be handled in a theoretic framework which denies the existence of derivational levels. Voicing assimilation applies within phrases (as, e.g., in Breton or Dutch; see Krämer 2000, Grijzenhout & Krämer 2000 and references therein, respectively), and tonal sandhi phenomena go over word boundaries within a prosodic phrase (see e.g. Wiese 1988 on Chinese). On the other hand, consonantal place assimilation and vowel harmony are restricted to the Prosodic Word or smaller domains (for a different view, cf. van der Hulst & van de Weijer 1995). In Optimality Theory, at least two explanations for the local restriction of vowel harmony and consonantal place assimilation are possible: the Output-Output Correspondence version of OT assumes that in larger units like compounds simplex output forms combine. For this reason harmony is limited to the respective members of a compound, instead of extending over the whole construction. The same must hold for phrases. Each word of a phrase is evaluated separately, and in the evaluation of the phrase, OO-faithfulness constraints have to rank above the constraints which demand harmony. Under the inverse ranking, harmony would extend over the whole phrase, which does not happen in the languages of the world. In such an analysis two questions arise, (i.) why is the ranking of OO faithfulness and harmony constraints never inverted?, and (ii.) why does this restriction not hold for voicing assimilation or tone sandhi? An alternative view is that compounds consist of different prosodic words as an effect of Alignment constraints on stems and prosodic words, and constraints on vowel harmony are limited to this domain (the prosodic word or something very similar). Furthermore, disharmony within single words can be accounted for under the assumption of underlying underspecification and prespecification, respectively. These last two assumptions are core ideas to be applied in this paper. With regard to the other assimilation phenomena, which apply to larger domains, it must be said in this account that probably the relevant constraints are simply not restricted locally. This may sound as a mere stipulation or description of the facts, but at least this approach has the advantage over the OO approach that universal differences among assimilation phenomena do not arise by a stipulated fixed universal ranking, but are an effect of the nature of the constraints themselves.

The effects that were modelled by derivational steps or levels and the location of particular rules on particular levels or their organisation in a certain order can be covered by Positional Faithfulness (Beckman 1995, 1997, 1998) or constraint domains (Buckley 1996a,b, Klein 1995) within Correspondence Theory. Positional Faithfulness instantiates special faithfulness constraints from more general ones in imposing a local restriction on the domain of their activity. For example IO-IDENT(F) demands output segments to be identical in feature specification to their correspondent input, while IO-IDENTONSET(F) is restricted to segments which are prosodified in an onset in the output (Lombardi 1999). Constraint domains, as proposed for example by Buckley (1996a,b) and Klein (1995) limit constraints to larger categories than (stressed) syllables or parts of syllables. They refer to morphological categories like 'root' or 'stem'. The same holds for the domain of locally conjoined constraints (Smolensky 1993). Even though it would be a useful restriction to the theory of Local Conjunction if constraint conjunctions were limited to the domain of the segment, some authors (e.g. Alderete 1997) proposed larger domains (e.g. compound words). That vowel harmony and consonantal place assimilation stop at word boundaries, while voicing assimilation and tone sandhi stop at phrase boundaries, can be accounted for by assuming that the responsible correspondence constraints are also subject to local restrictions to just these categories. That is, the constraint on moraic/syllabic featural S-IDENTITY holds only within a Prosodic Word, while S-IDENTITY[voice] for example is limited to a larger domain, the Prosodic Phrase.

(10) SYNTAGMATIC IDENTITY(F) (S-IDENT):
Let x be an entity of type T in *domain D* and y be any adjacent entity of type T in *domain D*, if x is [αF] then y is [αF].
T ∈ {segment, mora, syllable, foot}
Domain D ∈ {PPh, PWd, foot, syllable}
(Within the domain of a Prosodic Phrase, Prosodic Word, foot or syllable, a segment, mora, syllable or foot has to have the same value for a feature F as the adjacent segment, mora, syllable or foot in the string.)

This restriction to local domains also throws some light on one of the potential functions of such assimilation phenomena, which a level-based analysis obscures: Like stress assignment and syllabification, assimilation eventually serves to structure utterances. Assimilation lumps together certain pieces of speech and separates others, marking word boundaries and phrase boundaries.
Technically, this constraint is violated whenever features in adjacent categories do not agree in their respective specification. The constraint is vacuous in cases where features agree in nonadjacent categories or where features in adjacent categories agree beyond the scope of the constraint. Furthermore, I assume that only those elements that bear the same types of features stand in a syntagmatic correspondence relation. In the analysis of the Yucatec blocking pattern (section 3.2), I assume that vowels and consonants do not bear the same features (contrary to assumptions by Ní Chiosáin 1991, Clements & Hume 1995 and others). Therefore, they do not stand in a correspondence relation. Vowels are in correspondence with vowels, but not with consonants.[5]
Note finally that directionality of assimilation is not included any more in the mechanism of assimilation itself, as was done by rule accounts of the type [αF] → [βF]/__[βF], by Alignment constraints on features, or by the Constituent Concord approach. This omission of direct reference to directionality is necessary because in fact most cases of assimilation have no intrinsic direction. Directionality effects are caused by the interaction of independent faithfulness constraints with S-IDENTITY. This issue will be discussed in more detail in section 3.3.
In the following section, I will apply the model to Yucatec Maya vowel alternations.

3 Yucatec Maya vowel alternations

Yucatec Maya, a Mayan language spoken by roughly 700,000 people in south-eastern Mexico, Belize, and northern Guatemala (Lastra 1998, Lehmann 1990), has the vowels *i, e, a, o, u,* and distinguishes between long and short vowels. Among the long vowels, a distinction is made between high toned vowels and low toned (or neutral) ones. *a* is the default vowel, as will be shown in section 3.2. In backness dissimilation, *a* causes a following vowel to become [+back], as do the front vowels *i* and *e* (section 3.5), so *a* is [-back, -high, +low]. In height dissimilation, which affects the feature [±low], *e* behaves as low together with *a*, while *o*

[5] See footnote 11 for a further discussion of how the current model would look like under the assumption that features of vowels are of the same type as those of consonants.

behaves like a nonlow vowel (see section 3.5). Thus, *e* must be [-back, +high, +low], since it is also regarded as more marked than *a*, and *o* is [+back, -high, -low], deviating from *u* in the specification of the feature [±high]. Roundness of both back vowels is predictable and therefore arises in satisfaction of a feature cooccurence restriction, which demands back vowels to be rounded, i.e. *[+back, -round]. This results in the following feature matrix for the five Yucatec vowels.

(11) The Yucatec Maya vowel system

	i	e	a	o	u
back	-	-	-	+	+
high	+	+	-	-	+
low	-	+	+	-	-

A ranking of the markedness constraints *[+back] (i.e. 'avoid the feature specification [+back] in the output.') and *[+high] above *[+low] accounts for the choice of *a* as the default vowel instead of *e* or any other vowel. With these assumptions on the Yucatec vowel inventory as background, I will now proceed to the discussion of the alternation patterns.

3.1 Harmony and blocking by prespecification

In this language, some suffixes copy the last vowel of the stem completely (see 11a,b), while other suffixes display dissimilating patterns. The latter suffixes will be treated in section 3.4. Other Yucatec suffixes do not exhibit assimilatory or dissimilatory patterns of vowels at all (12c,d).
In (12a,b), the harmonising suffixes for imperfective and subjunctive of intransitive verbs are shown. The imperfective suffix for transitive verbs and the perfective suffix (attaching to both transitive and intransitive stems), on the other hand, never alternate in vowel quality (12c,d).

(12)Yucatec Maya harmony and disharmony:[6]

a. Intransitive imperfective

ʔah-al	wake.up-IMPF
ʔok-ol	enter-IMPF
lub'-ul	fall-IMPF
wen-el	sleep-IMPF
kíim-il	die-IMPF

b. Intransitive subjunctive

ʔah-ak	wake.up-SUBJ
ʔok-ok	enter-SUBJ
lub'-uk	fall-SUBJ
wen-ek	sleep-SUBJ
kíim-ik	die-SUBJ

c. Transitive imperfective

yil-ik	see-IMPF
tsol-ik	explain-IMPF
putʃ-ik	hit-IMPF

d. Perfective

yil-ah	see-PERF
tsol-ah	explain-PERF
putʃ-ah	hit-PERF

[6] The Yucatec data are taken from Ayres & Pfeiler (1997), Blair & Vermont-Salas (1967), Bricker & Po'ot Yah (1981), and Lehmann (1998). A list of all abbreviations used in the glosses can be found in the appendix.

On the basis of the examples above, we can conclude that in this language (where harmony is not broadly active) the non-alternating suffixes are fully specified whereas the harmonising ones are underspecified, as indicated in (13).

(13) a. Fully specified morphemes: /-ik/; /-ah/
b. Underspecified morphemes: /-Vl/; /-Vk/

This analysis is in line with Inkelas' (1994) assumptions on underspecification within Optimality Theory. Due to Lexicon Optimization (Prince & Smolensky 1993), non-alternating structure is fully specified underlyingly (avoiding DEP(Feature) violations) while alternating structure is underspecified (avoiding IO-IDENT(F) violations).

An alternative to the underspecification analysis would be one in which different constraint rankings for the two types of morphemes are assumed. This means in fact to tolerate morpheme-specific grammars. In consequence, this predicts that possibly a language may have one individual grammar for each morpheme of the language, which is highly implausible for reasons of economy and of learnability.

Usually, harmony affects only one or two features of a vowel. In Yucatec Maya harmony, almost all features seem to be involved, except length and tone. From the vowel inventory we know that roundness or ATR plays no role in this language. Both features are predictable. The remaining features which are relevant for the system and for harmony are [±high], [±low] and [±back] as well as length and tone. Underspecification of the affected vowels affects at least the first three features, because in the case of blocking of harmony, the relevant vowel surfaces as the default one *a* (see section 3.2). Furthermore, the underspecified/harmonising vowels do not alternate in length or tone in Yucatec Maya. This length and tone stability must be regarded as an argument against a reduplication analysis, because reduplication would copy all features. The S-IDENTITY constraint for vocalic features can be formulated as follows.

(14) Moraic SYNTAGMATIC IDENTITY (S-IDENTμ[b,h,l]):
Let x be a vowel in *mora* 1 and y be any correspondent of x in *mora* 2.
If x is [αback], [βhigh], [γlow] then y is [αback], [βhigh], [γlow].

The harmonic patterning is restricted to a handful of affixes. Consequently, S-IDENTITY has to be ranked below the relevant IO-IDENT(F) constraints on underlying vocalic features, see(15). Lexical entries have to be fully specified, except for alternating structure.

(15) IO-IDENT(F) >> S-IDENTμ[b,h,l]

The constraint MAX-IO, (McCarthy & Prince 1995:264) forces the underspecified vowel to surface even though the filling-up of the features, which are necessary for its pronunciation incurs DEP(F) violations. Thus, MAX-IO must be ranked above DEP(F) constraints.

(16) MAX-IO: Any segment in the input has a correspondent in the output.

(17) DEP(F): Any feature in the output has a correspondent in the input.

The effect of the proposed constraints is shown in the tableau below.

(18) Underspecification and harmony:

/lub'+Vl/	S-IDENTμ[b,h,l]	MAX-IO	DEP(F)
a. lub'al	*!*		*
b. lub'el	*!*		*
c. lub'ol	*!		*
d. lub'il	*!		*
e. lub'l		*!	
☞ f. lub'ul			*

The candidate *lub'ul* in (18f), is chosen as optimal because it parses the underspecified vowel and obeys S-IDENT in letting the features of this vowel agree with those of the vowel in the neighbouring mora. MAX-IO prohibits skipping the featureless segment in the output (form e), which would leave all other constraints unviolated. The ranking of MAX-IO with respect to the involved IDENT constraints cannot be determined on the basis of this data. It is crucial that it is located above any kind of DEP constraint. Filling in of features, which are not specified identically to those of the stem vowel, fatally violates S-IDENTITY (forms a-d).
Evaluating a form with a fully specified suffix, as in (19), does not only show that IO-IDENT(F) has to rank above S-IDENT, it shows also the relative importance of MAX-IO. Skipping one of the two vowels of the form would save a candidate from violating either IO-IDENT or S-IDENT (see candidates 19d,e). To prevent candidates (d,e) from surfacing the correct ranking has to be MAX-IO, IO-IDENT >> S-IDENT. In fast speech, however, vowels which are located between two other vowels are elided. This shows that in fast speech the ranking of MAX-IO with respect to S-IDENT is changed. I will postpone discussion of these facts until after the analysis of blocking and of regressive harmony with clitics, which are crucial for the analysis of syncope.

(19) Lexical specification and disharmony:

/tsol+ik/	MAX-IO	IO-IDENT(F)	S-IDENTμ[b,h,l]
a. tsolok		*!	
☞ b. tsolik			**
c. tsolak		*!	*
d. tsolk	*!		
e. tslik	*!		

In (19), IO-IDENT(F) rules out the candidate forms that override underlying feature specifications (a,c). This is crucial for fully specified elements, because in order to satisfy IO-IDENT(F), S-IDENTITY, which demands that a vowel should look like the one in the next mora, has to be violated.
The Yucatec harmony grammar established so far is summarised in(20).

(20) MAX-IO, IO-IDENT(F) >> S-IDENTμ[b,h,l] >> DEP(F)

With this basic grammar as a background, I turn now to the evaluation of harmony which is blocked by consonants.

3.2 Blocking by consonant clusters

In Yucatec Maya, harmony is blocked if more than one consonant is located between the two potentially involved vowels. (21) illustrates this with the subjunctive suffix, which normally echoes the root vowel (cf. 12b). In (21), the vowel of the subjunctive suffix surfaces as [*a*].

(21)	tùukul-n-ak[7]	think-N-SUBJ[8]	* tùukulnuk
	hèek'-n-ak	break-N-SUBJ	* hèek'nek
	ts'íib'-n-ak	write-N-SUBJ	* ts'íib'nik

The same holds for the other harmonising suffix in (12). The blocking effect due to an intervening consonant is illustrated in (22).

(22)	t'otʃ -b'-al	'to harden (glue)'	instead of * t'otʃ -b'-ol
	harden-PASS-IMPF		

A consonantal barrier, consisting of more than one consonant, thus blocks the 'transfer' of the vowel features from the stem to the affix. This blocking behaviour is also observed with roots with a final consonant cluster (although they are rare), which shows that this is not a morphematic restriction. This means that the possibility is excluded that adjacency (or locality) of harmonising or otherwise interacting elements is defined over morphemes, with intervening morphemes as blockers. Instead, phonological units block harmony.

It is a widely shared opinion that consonants in onset position do not contribute to the weight of a syllable, while consonants in coda position do contribute to the weight of a syllable in many languages. The weight of a syllable is measured by the unit mora (μ). A coda consonant which makes a syllable heavy projects a mora, while a coda consonant which has no effect on syllabic weight bears none. If, in Yucatec, only one consonant is found between two vowels it has to be an onset. In vowel-initial stems for example, an onset is provided by glottal stop insertion. Of the two consonants which are situated between non-corresponding vowels, the first one has to be a coda while the second is the onset of the next syllable. So, the former is probably moraic. If this is the case this consonantal mora between two vocalic moras may be the reason for the absence of harmony. In the following, I will first give evidence for coda moraicity in Yucatec Maya and then further use this fact to explain harmony blocking.

An ongoing discussion in the literature is whether Yucatec Maya has phonemic pitch accent or tones (see e.g. Pike 1946, Blair & Vermont-Salas 1967, Fisher 1976, Straight 1976, Lehmann 1990). Unfortunately, no work is done so far on the accentual system. Nevertheless, Pfeiler (p.c.) suggests that it is uncontroversial among Mayanists that Yucatec Maya is quant-

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7 Accents on vowels indicate high (grave accent) or low tone (accute accent). See also footnote 8 for a brief discussion of Yucatec tone.

8 The function of the suffix *-n-* is subject of an ongoing debate. Therefore it has no glossing. For differing proposals see Bricker (1978), Lucy (1994), Krämer & Wunderlich (1999).

ity-sensitive. According to Straight (1976:41), closed syllables (i.e. those ending in a consonant) have more weight than their open syllable counterparts in Yucatec Maya. However, he does not provide evidence for this claim. In many transcriptions (in particular those of Blair & Vermont-Salas 1967), phrasal intonation is indicated by little superscripts preceding and following each syllable, with ^{3} indicating high pitch and intensity, ^{2} indicating medially high, ^{1} lower than medial, and ∅ neutral intonation. Phonemic pitch accent, i.e. high and low or neutral tone,[9] is transcribed by an acute accent and a grave accent, respectively. The arrow at the end of each phrase in the examples below indicates whether the terminal intonation contour of a phrase is stable, falls or rises (to mark a question for example). Below are some intonation patterns of Yucatec Maya (as given in Blair & Vermont-Salas 1967), including some of the harmonising examples mentioned earlier. These data will serve to derive the relevant generalisations on Yucatec Maya stress in general and its quantity-sensitivity in particular.[10]

(23) a. ^{2}ka. wa.^{2}h-al^{2}→ 'you wake up'
b. ^{3}lúu.^{1}b'-ul^{1}→ 's/he falls'
c. ^{2}kiŋ. we.^{2}n-el^{2}→ 'I sleep'

(24) a. ^{2}ku. me.^{2}yah^{2}→ 'he works'
PR.3SG work
b. ^{2}h me.^{2}yah.-n-a.^{2}k-en^{1}↓ 'I have worked'
PAST work-N-SUBJ-1SG
c. ^{2}way. ka. me.ya.^{2}h-eʔ^{2}↑ 'Are you working here?'
Q PR-2 work-TERM

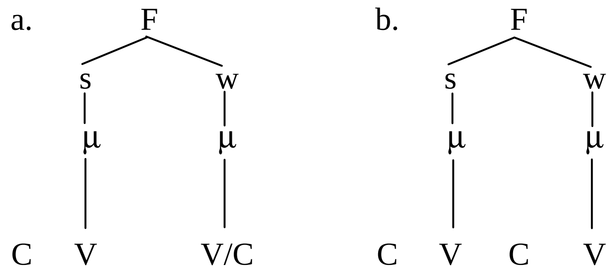
The last syllable of a word or phrase always has a higher intonation than neutral (23a-c, 24a-c). When the last syllable of a word or phrase is preceded by a high toned syllable, the latter gets higher or intenser intonation than the last one, which is still stressed. All Yucatec words end in a consonant. If they do not have one lexically, a glottal stop or glottal fricative is inserted. Thus, the last (the stressed) syllable is always heavy. The leftmost syllable attracts stress, too. Word-medial light syllables are usually not accented (24c) and thus I assume them to be unfooted. As we can see from the little superscripts, a word-medial CVC syllable gets an intonational marking (24b), so we can conclude that it is stressed or footed. That this syllable does not bear a lexical accent can be inferred from example (24c) where the same

[9] Mayanists do not agree whether low or high tone is the marked one in the system (if it is a tone system at all). According to Fisher (1976), who investigates phonetic pitch and intensity curves of Yucatec vowels, short vowels are neutral and have the same pitch as long low vowels. Long high vowels start with a higher pitch as low and short ones, then fall (Fisher 1976:37). Nevertheless, Lehmann (1990: footnote 1) groups short vowels together with high vowels, regarding low tone as the marked case and high tone as neutral.

[10] In phrases containing tone bearing morphemes, stress assignment is a little more complicated. For the sake of clarity, I exclude tone bearing material as far as possible from the considered data. The superscripts in (22,23) should be read as follows: If a syllable is preceded by a superscript, it starts on that level. If it is not followed by a superscript the intonation has arrived at neutral level at the end of that syllable, which is kept until the next superscript occurrs. Superscripts at the end of a word/syllable indicate at which level the syllable/word ends.

syllable is light and unaccented. These data show that Yucatec Maya is quantity-sensitive with coda consonants being moraic and thus contributing to the weight of a syllable.
In his phonetic measurements, Fisher (1976) found that high toned syllables (containing a long vowel) have a contour when in stressed position, that is, they abruptly rise from neutral to high pitch in the first half of the long vowel and then fall back to neutral in the second half. From the accent distribution data and Fisher's measurements, I conclude that in Yucatec Maya, trochaic bimoraic symmetric feet are built.

(25) Yucatec trochaic foot:
(s = strong, w = weak)
(μ = mora)



The diagram in (25) illustrates that the main characteristics of a Yucatec foot is bimoraicity, containing either one heavy syllable (CVV, CVC or heavier; see 25a) or two light ones (CV.CV; see 25b).
What can be observed in the data in (23,24) is that an accented foot is built at the right and at the left edge of a phrase or word. Heavy (CVC , CVV or heavier) syllables attract stress. Thus, Yucatec Maya has initial stress. Final stress arises by the interaction of the requirement to have a closed (CVC) syllable at the right word edge and the stress-to-weight principle, which also assigns stress to medial syllables in case they are heavy. If a phrase starts with two light syllables followed by a heavy one (23a), the first two syllables are grouped into a bisyllabic bimoraic foot and the heavy syllable is one bimoraic foot of its own. The foot structures are illustrated by the rightmost column in (26).

(26)

a.	^{2}ka wa.^{2}h-al^2→	'you wake up'	$(\text{ka.wa})_F$ $(\text{hal})_F$
b.	^{3}lúu.^{1}b'-ul^1→	's/he falls'	$(\text{lúu})_F$ $(\text{bul})_F$
c.	^{2}kiŋ we.^{2}n-el^2→	'I sleep'	$(\text{kiŋ})_F$ we $(\text{nel})_F$
d.	^{2}ku me.^{2}yah^2→ PR.3SG work	'he works'	$(\text{ku.me})_F(\text{yah})_F$
e.	^{2}way ka me.ya.^{2}h-eʔ^2↑ Q PR-2 work-TERM	'Are you working here?'	$(\text{way})_F$ ka.me.ya $(\text{heʔ})_F$
f.	^{2}h me.^{2}yah.-n-a.^{2}k-en^1↓ PAST work-N-SUBJ-1SG	'I have worked'	$(\text{h.me})_F$ $(\text{yah})_F$na $(\text{ken})_F$

As said already, Piggott (1996) analyses nasal harmony in Lamba as harmony from syllable to syllable, and Kikongo nasal harmony as agreement between feet. From these findings the possibility arises that the foot may be the domain of harmony in Yucatec Maya, and that harmony stops at the foot boundary. This would be an alternative to the moraic account argued for in this paper. Consider in this respect once more example (23b) repeated here as (27).

(27) a. ^{3}lúu.^{1}b'ul^1→ 's/he falls' b. $(\text{lúu})_F$ $(\text{bul})_F$ c. *$(\text{lúu})_F$ $(\text{b}\textbf{a}\text{l})_F$

According to the assumptions of moraic weight and foot structure in Yucatec Maya, (27b) is the correct prosodic analysis for (27a). Under the assumption of foot-internal harmony, harmony should be blocked, since the underspecified vowel of the suffix /*-Vl*/ is not in the same foot as the stem vowel. The expected output is (27c), which is not the case. Thus, the Yucatec blocking effect cannot be attributed to foot structure.

The insights from this short excursion to stress patterns are that coda consonants count as a mora in this language and that the foot is not relevant to the harmony patterns under investigation. This supports the assumption that blocking of harmony can be explained by the existence of a consonantal mora (i.e., one without vocalic features) between two vowels. With this in mind we can proceed to the discussion of the treatment of harmony and its blocking.

The diagram below illustrates how moraic harmony is blocked when a consonant bears a mora between two vocalic moras which should otherwise interact. I assume that consonants do not carry vocalic features. If one of two feature bearing elements lacks the respective features (i.e., is a consonant) there is no base for an Identity relation. Establishing this relation with the next feature bearing element by skipping a featureless one violates the locality condition of S-IDENTITY (i.e., that corresponding moras have to be adjacent). Such a nonlocal correspondence relation is neither demanded nor protected by any faithfulness constraint.[11]

(28) *tuukulnak* 'think' (subjunctive form)

tu		u		ku		l		na		k
|		|		|		|		|		|
μ	↔	μ	↔	μ	↮	μ	↮	μ	↮	μ
	[±F]		[±F]		[±F]		[±F]		[±F]	

A different line of argumentation is found in Ní Chiosáin & Padgett (1997), who argue that harmony goes from segment to segment. They assume the 'bottleneck effect' to exclude long distance consonantal spreading. Vowels are changed into consonants if consonantal place features spread onto them, resulting in homorganic CCCCC sequences from underlying /CVCVC/ segments. Consonants instead do not change into vowels if vocalic features are coarticulated on them. An explanation in the sense of Ní Chiosáin & Padgett for the blocking effect observed in Yucatec Maya would be that over two consonants the speech organs have enough time to return to rest position. So this kind of blocking would be an instance of articulatory laziness. The question remains why in other languages – like Turkish – coda consonants have no opacity effect on vowel harmony. Are Turkish speakers less lazy than Yucatecans? In the approach given in this paper, the answer is quite straightforward: In many languages, coda consonants do project a mora but do not have any influence on vowel harmony. In these languages, the harmony constraint operates on syllables instead of moras. This

[11] An alternative view would be that consonants bear vocalic features, too (in accordance with proposals by Ní Chiosáin 1991, Clements & Hume 1995 and others). In that case, consonant specific faithfulness is ranked higher than S-IDENTITY in Yucatec. IO-IDENTITY$_{consonant}$ militates against consonants participating as targets of harmony, and INTEGRITY(F)$_{consonant}$ militates against consonants acting as triggers of harmony (for a definition of INTEGRITY see below in section 3.3.2). Note that a decision on this issue has no influence on the assumed role of the mora in Yucatec Maya harmony. For the sake of clarity, I will proceed with the analysis without discussing this issue any further.

may also be an explanation why the Yucatec blocking pattern is so rare cross-linguistically: On the one hand, the relevant category is the mora, on the other, coda consonants are moraic. The chances that both facts coincide in one language must be regarded as rather low.

In tableau (29), where the blocking case is evaluated, S-IDENTITY is not violated in candidates (b-f), even though two vocalic moras are not identical in most cases, and in candidate (c), two moras agree, having a consonantal mora between them. Exactly because of this intervening consonantal mora the adjacency requirement is not met, which is incorporated into the definition of S-IDENT, i.e. corresponding moras have to be adjacent. In nonadjacent moras, no correspondence relation is established. The choice of the right feature profile is passed down to the markedness constraints in such a case.

(29) Harmony blocking:

/tuukul+n+Vk/	MAX-IO	IO-IDENT(F)	S-IDENT$_{\mu[F]}$	*[+back]	*[+high]	*[+low]
a. tuukulnk	*!					
b. tuukuln**o**k				*!		
c. tuukuln**u**k				*!	*	
d. tuukuln**i**k					*!	
e. tuukuln**e**k					*!	*
☞ f. tuukuln**a**k						*

Candidates (b-f) show that the language-particular ranking of featural Markedness constraints (i.e., *[+back], *[+high] above *[+low]) accounts for the choice of the right vowel in case harmony is blocked and the features of the underspecified vowel cannot be licensed via Syntagmatic correspondence. Note that even the least marked vowel incurs markedness violations, since it has to be fully specified on the surface. It is only that the relevant markedness constraints are the lowest in the hierarchy. This surface feature specification of the least marked vowel also prevents all lexical *a*'s from being overwritten by the neighbouring vowel features in the respective context. For example the *a* of the suffix *-ah* in *yilah* 's/he saw' (12d) would have no surface feature specifications in a system relying on privative features and would be expected to turn out as **yilih* according to the grammar developed in this paper, since no IO-IDENTITY were to be maintained in case of /a/, and the candidate with the least violations of S-IDENT would win, which is the fully harmonic form **yilih.*

An anonymous ZS reviewer wondered whether data like *hèek'nak* 'break-SUBJUNCTIVE' posed a problem for the analysis provided here, because in such a word the first syllable *hèek* would have two moras on the long vowel leaving the coda consonant without a mora and, thus, not capable of blocking harmony. One reason why the coda consonant should not be assigned a mora automatically, is – of course – Foot Binarity, the constraint which demands that feet consist of two moras or syllables. A trimoraic syllable cannot be footed as elegantly as a bi-moraic one. Straight's (1976:41) generalisation that closed syllables (i.e. those ending in a consonant) have more weight than their open syllable counterparts in Yucatec Maya includes syllables with long vowels as well. If we accept his observation, we must assume a ranking where a constraint which prefers syllables with moraic codas (call it Weight-by-Position) is ranked higher than Foot Binarity. Such a ranking creates superheavy syllables, which are tri-moraic, hence block harmony.

The next section focuses on an intrinsic property of the alignment approach and the rule based account of feature assimilation which the current proposal lacks: the directionality of the process.

3.3 Directionality of vowel harmony

In this section, I will show that Yucatec Maya vowel harmony has no intrinsic restriction on the direction of the assimilation process. Apparent directionality effects arise independently by Positional Faithfulness[12], and in this particular case by a distinction between stem faithfulness and affix faithfulness (probably responsible for the direction of vowel harmony in many languages).[13]

3.3.1 Regressive harmony

In the preceding sections, we have seen that Yucatec Maya harmony usually applies from left to right, i.e. the last stem vowel determines the shape of the following suffix vowel. This generalisation does not entirely cover the Yucatec data. An example of regressive vowel harmony can be found in the clitic cluster in front of verbs and nouns. If two clitics are combined, the rightmost vowel can give its quality to its neighbour to the left. Harmony is optional in this case, with harmony in fast speech and lack thereof in careful speech. Interestingly, harmony overrides even underlyingly specified vowel features in the clitic cluster. In this environment, the assimilation is never progressive. Accordingly, the clitics never assimilate to the root. In example (30a-c), the person clitics trigger complete harmony in the preceding tense/mood/aspect particle.

(30) a. héʔ in b'in-eʔ / híʔ in b'ineʔ
FUT 1SG go-TERM
'I will go.'

b. héʔ a b'in-eʔ / háʔ a b'ineʔ
FUT 2SG go-TERM
'You will go.'

c. héʔ u b'in-eʔ / húʔ u b'ineʔ
FUT 3SG go-TERM
'S/he will go.'

Consonant-final clitics do not syllabify with following vowel-initial stems. Instead of the clitic-final consonant, a glottal stop is inserted stem-initially in order to provide an onset. Even though morpho-syntactically related to the following noun or verb, this auxiliary group (the clitics) is prosodified in the preceding word, if one is available (cf. Lehmann 1998:34).

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[12] See for example Lombardi (1999) who uses the asymmetry between ONSETFAITH and general FAITH to explain the mostly regressive nature of obstruent voicing assimilation.

[13] See also the argumentation against an incorporation of directionality into a theory of assimilation in Baković (2000) and references cited there.

(31) [miʔn wohlu k'à:baʔiʔ]
ma' in w-ohel u k'àaba'-i'
NEG 1.SG know 3 name-NEGF
'I don't know his name'

In example (31), the clitic *u* which encodes the possessor of the following noun *k'àaba'* 'name', is syllabified with the preceding verb *ohel* 'know'. If no host is available, these clitics constitute one prosodic unit of their own, as the negative particle and the first person clitic in (31). Since they are within a prosodic word, S-IDENTITY is also valid for clitics. As one can see in examples (30b,c), the clitic containing information on person often consists of only one vowel, *u* for third singular, and *a* for second singular. If this vowel were overwritten with the features of the preceding vowel, person information could not be identified anymore. Therefore, I assume that the direction of assimilation is influenced in this case by a highly ranked faithfulness constraint on morphological information, like MORPHOLOGICAL TRANSPARENCY (Canclini 1999: 63).[14]

(32) MORPHOLOGICAL TRANSPARENCY (MT): Morphological information in the input must be transparent in the output.

In a candidate like **héʔ e b'in-eʔ* in correspondence to the input /*héʔ+a + b'in+e*/ 'you will go', the information for second person, encoded by the vowel quality of the clitic /*a*/, would not be interpretable. The input /héʔ+u + b'in+e/ 's/he will go' could be encoded by this candidate as well. Thus, the feature [+2] is not mapped from the input to the output structure. Such a lack of morphological interpretability counts as a fatal violation of MT in the tableaux in (34) where just this form is evaluated. Assimilation of underlyingly specified vowels of clitics results from a weaker input-output faithfulness for clitics than for the material contained in the core morphological word (i.e, stem plus affixes). Optionality of harmony within the clitic cluster is an effect of a reranking of S-IDENT and faithfulness to clitics, as indicated in (33). Faithfulness to clitics is regulated by general Faithfulness in (33), while faithfulness to affixed forms is covered by IO-IDENT$_{MWd}$ (IO-Identity to the Morphological Word). The ranking in (33a) is valid for slow speech, while the ranking in (33b) accounts for fast speech, with promotion of S-IDENT above simple faithfulness. Faithfulness to lexical items contained within a morphological word (or 'maximal lexical projection') is still top-ranked – here abbreviated as IO-IDENT$_{MWd}$.[15]

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[14] For an alternative formulation of the same idea see Popescu's (2000:788) constraint MAX(M-F) ('Morphological features in the input must have a correspondent in the output.'), or PARSE-F ('Outputs contain all input features.') which is interpreted as a faithfulness constraint on syntactic features by Legendre, Wilson, Smolensky, Homer & Raymond (1995) and by Legendre (1996 and elsewhere).

[15] One might suspect that this particular faithfulness to the morphological word is an effect of Output-Output correspondence of the complex form with a simpler form which lacks the clitics. Under such a view the problem arises what serves as the base. Verb stems almost always appear with a preceding clitic group, except for intransitive verbs in the perfective aspect.

(33) a. MT, IO-IDENT$_{MWd}$ >> IO-IDENT >> S-IDENT
b. MT, IO-IDENT$_{MWd}$ >> S-IDENT >> IO-IDENT

In the tableaux (34i) and (34ii), the two outputs for underlying /*héʔa b'in-e*/ 'you will go' are evaluated in careful speech and fast speech, respectively.

(34) Optional regressive vowel harmony in clitics

i. Careful speech, no harmony: *héʔa b'in-eʔ* 'you will go'

/héʔ a b'in+eʔ/	MT	IO-IDENT$_{MWd}$	IO-IDENT	S-IDENT
☞ a. héʔa b'ineʔ				**
b. héʔ b'ineʔ	*! (2sg)			*
c. héʔe b'ineʔ	*! (2sg)		*	*
✋ d. háʔa b'ineʔ			*!	*
e. héʔe b'iniʔ	*! (2sg)	*	*	

ii. Fast speech, harmony: *háʔa b'in-eʔ* 'you will go'

/héʔ a b'in+eʔ/	MT	IO-IDENT$_{MWd}$	S-IDENT	IO-IDENT
✋ a. héʔa b'ineʔ			**!	
b. héʔ b'ineʔ	*! (2sg)		*	
c. héʔe b'ineʔ	*! (2sg)		*	*
☞ d. háʔa b'ineʔ			*	*
e. héʔe b'iniʔ	*! (2sg)	*		*

In the two tableaux, the winning candidate is indicated by the pointing finger as usual. The suboptimal candidate which would be the winner in the other speech register, respectively, is marked by a waving hand to facilitate candidate comparison. What becomes obvious is that the crucial difference between both registers is the reranking of S-IDENT and IO-IDENT with regard to each other. As far as the directionality issue is concerned in fast speech, where vowel harmony applies, it is the constraint on Morphological Transparency (MT), which rules out the candidates with progressive assimilation (34c,e). The vocalic features are essential for the identity of the second person marker *a*. The auxiliary denoting that the action takes place in the future consists of more phonological material. Therefore, the information 'future' is not lost, when the vowel of the auxiliary differs in its feature specifications from the input.
After the discussion of regressive harmony in the clitic cluster, I proceed to the discussion of the lack thereof within affixed forms.

3.3.2 Absence of regressive harmony

The data in (30) illustrated that the vocalic assimilation pattern can also be regressive in Yucatec Maya. From this, one would expect that harmony applies regressively if a suffix containing an underspecified vowel is followed by a morpheme with a specified vowel, and

In the remainder of this paper, clitics play almost no role. Therefore, IO-IDENT refers to IO-IDENT$_{MWd}$ in the following, while lower ranking general faithfulness is left out of consideration for the sake of simplicity.

harmony with the stem vowel is blocked. Affixes marking person and number potentially follow the subjunctive marker -*Vk*, as can be seen in (35a,b). Harmony does not apply from right to left in this context when it is blocked between the stem vowel and an underspecified suffix vowel.

(35) Blocking and directionality of harmony:

a.	káʔah	tʃuy-l-ak-en	b.	káʔah	tʃuy-l-ak-óʔob'
	occur	hang-POS-SUBJ-1.SG		occur	hang-POS-SUBJ-PL
	'I might hang.'			'They might hang.'	

Once we have abandoned the Alignment approach to assimilation including its left/right parametrisation we face a problem with such data: When harmony is blocked by a preceding consonant cluster (as in 35a,b), the vowel of the subjunctive affix should copy the features of the following vowel, if harmony were not restricted in directionality. But it does not, as shown in example (35). One might ascribe this directionality effect to Positional Faithfulness, which is encoded in the division of faithfulness constraints into FAITHStem and FAITHAffix, as postulated by McCarthy & Prince (1995). Baković (2000) argues for similar cases in Turkish that Positional Faithfulness is not capable to treat such instances of directionality.[16] This is indeed true if we consider Identity constraints only, because the underspecified affix does neither belong to the root (and as an inflectional affix nor to the stem, if we assume that only derivational affixes form new stems with the root), nor has it any IO faithfulness to maintain. The following analysis relies crucially on the affix-stem asymmetry of another Faithfulness constraint: McCarthy & Prince (1995:372) propose the faithfulness constraint INTEGRITY to exclude an input from mapping to several outputs (as in gemination or reduplication), as cited in (36).

(36) INTEGRITY — "No Breaking"

No element of S_1 has multiple correspondents in S_2.

For $x \in S_1$ and $w, z \in S_2$, if $x \Re w$ and $x \Re z$, then $w = z$.

A basic defining element of this constraint is the notion "element". What is meant by "element" by McCarthy & Prince is in fact the "segment", but an element may also be a feature. So INTEGRITY can in principle be extended to INTEGRITY(feature).

(37) INTEGRITY(F)

No feature of S_1 has multiple correspondents in S_2.

With INTEGRITY separated into atomic constraints like this, one can ascribe the Yucatec blocking effect to the ranking of INTEGRITY(F)Affix ('No affix feature has multiple correspondents') above S-IDENT, which in turn is ranked above general INTEGRITY(F) ('No feature has multiple correspondents'). This grammar is shown at work in tableau (38).

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[16] Baković discusses in particular why in forms like Turkish *gel-iyor* 'coming' the medial *i* agrees in backness and roundness with the stem vowel (*gel*) and not with the opaque affix vowel *o*. The analysis developed here can be extended straightforwardly to such data.

(38) Featural integrity: *tʃuylaken* 'I might hang'

/tʃuy+l+Vk+en/	IO-IDENT(F)	INTEGRITY (F)Affix	S-IDENT$_{\mu[F]}$	INTEGRITY (F)	*[+back], *[+high]	*[+LOW]
a. tʃuyl**u**k**u**n	*!		*		** ** **	
b. tʃuyl**a**k**a**n	*!				**	* *
c. tʃuyl**e**ken		*!		*	** * *	* *
d. tʃuyl**u**ken			*		** **! *	*
☞ e. tʃuylaken			*		** *	* *

Leftward spreading of vocalic features as in candidate (c) is ruled out by high ranking INTEGRITYAffix. The other undesired candidates lose by the mechanisms discussed above. Candidates (a,b) lose for having changed the surface feature values of the last underlyingly specified affix vowel, violating IO-IDENT(F). Candidate (d) ties with candidate (e) with regard to high ranking S-IDENT, but it is more marked than the last candidate. This grammar still allows for the regressive harmony in clitic contexts, since clitics are not affixes. They require a special status somewhere between stems and affixes, and thus are not affected by INTEGRITYAffix.

The distinction of INTEGRITY(F) into affix integrity and general integrity covers an interesting observation with regard to vowel harmony: Among the languages of the world no language has been found to date where affixes systematically control harmony. Harmony is either controlled by a dominant feature or by the stem. Nevertheless, the ranking of S-IDENT above INTEGRITY(F)Affix, which is automatically ranked above INTEGRITY(F) by their specific-to-general relation, naturally allows active participation of affixes as well as stem control in harmonic systems. However, affixes are usually not referred to in positional faithfulness constraints. Of the two categories it is the stem which is prominent, not the affix. This prominence relation (i.e. stem > affix) is captured in this special instantiation of positional faithfulness (i.e. INTEGRITY) by reference to the affix. It is the less prominent element to which the prominence decreasing constraint refers, while nonaffixes may be allowed more easily to increase their prominence in violation of lower ranking general INTEGRITY.

The next subsection will be devoted to the skipping of vowels, which will be explained by the harmony grammar developed so far.

3.4 Vowel elision

The ranking of MAX-IO with regard to S-IDENT, which was motivated in section 3.1, raises the question whether a pattern exists in which vowels are not realised in order to avoid violations of S-IDENT.[17] This would be predicted by the possible ranking of IO-IDENT(F) above S-IDENT, and S-IDENT above MAX-IO. See tableau (39).

[17] I would like to thank an anonymous reviewer of ZS for giving this suggestion.

(39) Hypothetical elision caused by S-IDENT:

/C V_{+F} C+V_{-F} C/	IO-IDENT(F)	S-IDENTμ[b,h,l]	MAX-IO
a. C V_{+F} C V_{-F} C		*!	
b. C V_{+F} C V_{+F} C	*!		
☞ c. C V_{+F} C < > C			*

In fast speech, syncope of certain vowels is observed in Yucatec Maya. In the examples in (40), column 2 is in slow speech, while the phrases in column 3 are uttered with a higher speech rate. The penultimate vowel is consequently left unparsed in faster speech. The purpose of this is to avoid violations of S-IDENT. By omission of the medial vowel, the speakers create a consonant cluster between the two remaining vowels. The first consonant in coda position blocks the instantiation of an S-IDENT relation.

(40)	Slow speech:	Fast speech:	
a.	ʔa wíitʃ'*i*n-óʔob'	ʔa wíitʃ'nóʔob'	'your brothers'
	2 brother-PL		
b.	tu láak*a*l-éʔeʃ	tu láakléʔeʃ	'you all'
	3 all-2PL		
c.	ʔa woh*e*l-éʔeʃ	ʔa wohléʔeʃ	'you (pl.) know'
	2 know-2PL		
d.	ʔiŋ k'ahóol-t-*i*k-etʃ	ʔiŋ k'ahóoltketʃ	'I know you'
	1 know-TRANS-IMPF-2		

If the vowel under discussion were not left unparsed, the grammar would count S-IDENT violations between the last and the penultimate vowel (40d), or – even worse – violations of S-IDENT regarding the relation of the penultimate vowel with the antepenultimate as well as of the penultimate with the ultimate vowel. The skipping of the second-last vowel to avoid at least S-IDENT violations with regard to the last one is illustrated in tableau (41).

(41) Fast speech *ʔiŋ k'ahóoltketʃ* 'I know you'

/in k'ahóol+t+ik+etʃ/	IO-IDENT(F)	S-IDENTμ[b,h,l]	MAX-IO
a. iŋ k'ahóoltiketʃ		* *!	
b. iŋ k'ahóolteketʃ	*!	*	
☞ c. iŋ k'ahóoltketʃ		*	*

In tableau (41), the ranking of S-IDENT above MAX-IO is crucial. All candidates violate S-IDENT twice because all have an *a* moraically adjacent to an *o*, with a difference in the features [±low] and [±back]. Candidate (a) violates S-IDENT a third time by mapping the underlying *i* and underlying *e* of the last two suffixes faithfully to the surface. They don't agree in height. Candidate (b) escapes from this violation, because the last two vowels are identical. This results in a fatal violation of a higher constraint, IO-IDENT. The last candidate applies a different strategy to reduce violations of highly ranking constraints: The candidate skips a vowel in violation of low ranking MAX-IO. This makes candidate (c) optimal. This ranking of MAX-IO below both types of Identity constraints is exactly the difference in the constraint hierarchy with respect to the slow speech grammar. In the slow speech grammar, Input-Output faithfulness (i.e. MAX-IO) is more important than harmony, compare tableau (42).

(42) Careful speech *ʔiŋ k'ahóoltiketʃ* 'I know you'

/in k'ahóol+t+ik+etʃ/	IO-IDENT(F)	MAX-IO	S-IDENTμ[b,h,l]
☞ a. iŋ k'ahóoltiketʃ			* *
b. iŋ k'ahóolteketʃ	*!		*
c. iŋ k'ahóoltketʃ		*!	*

In fast speech, S-IDENT is promoted over MAX-IO in the hierarchy. This is not surprising if one assumes that one driving force behind harmony or assimilation in general is ease of articulation. With regard to backness and height, it seems to be easier to return to a previously held position after a consonant than to approach a new tongue position.
The same elision phenomenon is rather regular with underspecified vowels in penultimate position. As can be inferred from example (43).

(43) a. tan u luk'-*u*l 's/he is leaving'
PRES 3 leave-IMPF
b. tan u luk'*u*le máak-o' 'the/that man is leaving'
PRES 3 leave-IMPF-DET man-DEM
c. tan u lu*k'l*e máako' 'the/that man is leaving'

Since the determiner *le* in (43b,c) is a weak element and cliticises to the preceding word, it is in ultimate position in this word. Geminates are not allowed in Yucatec. Degemination causes that the penultimate syllable has no coda anymore. This leaves the underspecified vowel in the second-last, light syllable. In this position it is in conflict whether to agree with the preceding or the following vowel. In fast speech the vowel is skipped to resolve this conflict, see example (43c) and the evaluation in (44).

(44) Fast speech and underspecified vowels

/... luk'+Vl # le .../	IO-IDENT(F)	S-IDENTμ[b,h,l]	MAX-IO
a. luk'ule		*!	
b. luk'ele		*!	*
☞ c. luk'le			*

The question may arise why it is not the vowel of the clitic (i.e., the *e*), which is skipped. Since clitics are weak elements by nature, they should be particularly prone to deletion. If the clitic vowel were not parsed, the information provided by the clitic (i.e. definiteness) would be lost in the surface form.
The fact that final underlyingly specified (viz. disharmonic) vowels are generally not skipped in fast speech (see the example below) to avoid S-IDENT violations must be attributed either to their prominence, or to reasons of syllable wellformedness. In the last syllable of a word, they are also within a foot, in which they are not when in the penultimate syllable. Under the assumptions that (i.) reranking affects only constraints which are adjacent in the hierarchy and that (ii.) positional faithfulness universally has to rank above general faithfulness, we get

MAX-IO(foot) ranked above MAX-IO, which is above S-IDENT in the slow speech grammar. One-step promotion of S-IDENT in the fast speech grammar yields MAX-IO(foot) above S-IDENT, and S-IDENT above MAX-IO. The latter ranking predicts that a disharmonic vowel in the last syllable of a word cannot be skipped. On the other hand, skipping the last vowel would result in a last syllable with a complex coda (CVCC) in most cases, which must be regarded as a highly marked syllable structure in Yucatec.

(45) /k k ts'on-ik/ kts'onik *kts'onk 'we're shooting it'
PRES 3pl shoot-IMPF

In the next section, a completely different question will be addressed: How can it be explained in a non-derivational model that the same language also displays a vocalic dissimilation pattern?

3.5 Dissimilation

In this section, I will investigate morpheme-specific dissimilation of backness and height in Yucatec Maya. These phenomena occur in two derivational morphemes. The affix which derives causative verbs from adjectival or nominal roots dissimilates in backness with the preceding root vowel, while the affix which is set between base and reduplicant when a certain type of verbal participle is formed dissimilates in height from the surrounding vowels. It will be shown that dissimilation of backness is limited in this case to a more narrow domain than harmony, in particular to that of the stem.

Vowel dissimilation with regard to backness is observed with only one suffix, a stem-forming derivational suffix on denominal and deadjectival verbs. The vowel of the suffix /-*kVː*$^{[+high]}$*n*/ surfaces as long [*u*] after front vowels and as [*i*] after back vowels. This is illustrated with stems containing the vowels *u*, *a* (*a* is a front vowel in Yucatec), and *i* in (46).

(46) Dissimilation of -/*kVː*$^{[+high]}$*n*/

a. uts-kiin-t-ik 'enhance/repair sthg.'
good-D-TR-IMPF

b. haw-kuun-t-ah 'lay sthg. down face up'
lie.down.face.up-D-TR-PERF

c. sáasil-kuun-s le k'oʔob'en-oʔ! 'Light up the/that kitchen!'
light.up-D-CAUS DET kitchen-DEM

Since the affix always occurs with a high vowel I regard height as prespecified lexically, as indicated in the notation above. The whole pattern can be described as in the following table.

(47) Dissimilation pattern:

Stem	affix
C*i*C, C*e*C, C*a*C	-*kuun*

stem	affix
C*u*C, C*o*C	-*kiin*

Yucatec stems almost always end in a consonant. As this affix has an initial consonant, the result is an intervening consonant cluster in all cases. Vowel dissimilation takes place in this context, where, as we saw earlier, harmony would be blocked.

Such a dissimilation pattern may be analysed as an effect of the Obligatory Contour Principle (OCP; Leben 1973, Goldsmith 1976, McCarthy 1986). The OCP has been incorporated into OT as a Local Conjunction of Markedness constraints by Alderete (1997).

(48) *OCP effects are derived by markedness constraints, doubled in a local context.* (Alderete 1997:18) *(feature)^{2}L. L = local domain, e.g. stem

A theoretically more economic and conceptually more adequate solution would be to formalise dissimilation analogous to assimilation. In his examination of morphological haplology, Plag (1998) proposes to regard OCP effects as an instance of misidentity or unfaithfulness between parts of one representational string. He formulates an OCP on nuclei as 'no identical nuclei in adjacent syllables' (Plag 1998:206). My proposal parallels this view in that I regard dissimilation as a principled violation of correspondence constraints affecting adjacent syllables, so to say *S-IDENTITYσ. As I have shown above, dissimilation happens in a segmental context where harmony would be blocked in Yucatec. One cannot switch off mora assignment to codas for that particular morpheme. So, is dissimilation in contrast to assimilation not local? Here the locality theorem can be saved if one assumes that it is dissimilation in backness between syllables what happens here. What one gets by regarding dissimilation as the violation of a syntagmatic identity constraint is in fact a complex markedness constraint ranging over neighbouring segmental or prosodic categories and affecting the respectively associated features.
Now I will consider the OCP constraint at work in Yucatec Maya. The OCP active in Yucatec Maya can be formulated as follows.

(49) The backness OCP: *S-IDENTITYσ[bck] (preliminary definition):
Let *x* be a syllable in domain D and *y* be any adjacent syllable in domain D, if *x* is [αback] then *y* is **not** [αback].
Domain D $\in$ {?}

Expressed in nontechnical terms, this constraint is violated whenever two syllabically adjacent backness specifications are the same. One can satisfy this constraint in three ways: by dissimilation, by deletion of one of the feature bearing units in question or by epenthesis of an intervening neutral element or a feature bearer with opposite feature specification.
Highly ranked, this constraint produces sequences of, e.g., back-nonback-back-nonback syllables. Unfortunately, this would override any kind of harmony. So the constraint on moraic harmony must be ranked above the OCP constraint.

(50) S-IDENT$\mu_{[b,h,l]}$ >> *S-IDENT$\sigma_{[bck]}$

Furthermore, there is no dissimilation of the underspecified inflectional affixes to the stem vowel when harmony is blocked. With the given ranking, exactly in this environment dissimilation should apply.

(51) Unattested overapplication of dissimilation

	/ts'íib'+n+Vk/	S-IDENTμ[b,h,l]	*S-IDENTσ[bck]
	a. ts'íib'nik	✓	*!
☠	b. ts'íib'nok	✓	✓
☹	c. ts'íib'nak	✓	*!

In tableau (51), the ☹ marks the actual output of the Yucatec grammar, and the ☠ marks the output of this OT grammar. The harmonic candidate (a) is ruled out for violating *S-IDENTITY. The same holds for the desired candidate (c). A closer look at the morphological nature of the affixes under discussion provides the missing insight to construct an appropriate grammar: The dissimilating affix is derivational, i.e. stem-forming. It derives verbs out of adjectives and nouns. From this I conclude that backness dissimilation is locally restricted to the domain of the stem, to which inflectional affixes do not belong.

(52) *S-IDENTσ[back]: Domain = stem.

(53) Nonapplication: locally restricted dissimilation

	/ts'íib'+n+Vk/	S-IDENTμ[b,h,l]	*S-IDENTσ[bck]$_{stem}$	*[+back], *[+high]	*[+low]
	a. ts'íib']nik			*!	
	b. ts'íib']nok			*!	
☞	c. ts'íib']nak				*

The square bracket in tableau (53) indicates the right stem boundary. Candidate (a) is rejected because it violates higher ranked markedness constraints than the winning candidate (c). Candidate (b) has dissimilated backness values as *S-IDENT demands, but the dissimilation goes beyond the domain of this constraint, since the dissimilating affix vowel is not part of the stem. Since *S-IDENT is vacuous beyond its domain, the decision is passed down to the markedness constraints. The ranking of *[+back] and *[+high] above *[+low] rules out candidates (a) and (b). Candidate (c) is almost perfect. As mentioned already in section 3.2, insertion of feature specifications for *a* violates only the lowest ranked markedness constraints in the Yucatec hierarchy, i.e. *[+low].

In the tableau below we see the grammar construed so far in action, evaluating the actually occurring dissimilative pattern.

(54) Evaluation of vowel disharmony for /-*kV:*$^{[+high]}$*n*/:

	/uts+kV:$^{[+high]}$n+t+ik/	IO-IDENT[bck]	IO-IDENT[high]	S-IDENT	*S-IDENT$_{stem}$
	a. **i**ts.k**u:**n]tik	*!			
	b. **i**ts.k**i:**n]tik	*!			*
	c. uts.k**u:**n]tuk	*!			*
	d. uts.ka:n]tik		*!		
	e. uts.k**e:**n]tik		*!		
	f. uts.k**u:**n]tik				*!
☞	g. uts.k**i:**n]tik				

In tableau (54), the first two candidates (a,b) are trivially ruled out because the stem vowel is underlyingly specified for its feature values. The emergence of the vowel *a* in the stem-forming suffix (54d) is odd, because the vowel of the first suffix underlyingly contains the feature [+high] which has to be identical to the surface form in satisfaction of IDENT[high]. This feature specification is contradictory to the feature profile of the Yucatec unmarked vowel. The same holds for candidate (e); IDENT[high] is violated by this form. The form with identical vowels in (c) is out because both have the same backness value, which violates *S-IDENT. Identity feature constraints have to be ranked higher than *S-IDENT in order to prevent polysyllabic stems and compounds in Yucatec Maya from undergoing dissimilation. S-IDENT, the constraint responsible for harmony, is satisfied vacuously by all candidates, because all syllables are closed by consonants. So there are no adjacent vocalic moras. Note finally that the dissimilating suffix itself contains a long vowel, that is two adjacent vocalic moras which agree in feature specification. This is automatically accounted for by the ranking of S-IDENTμ above *S-IDENTσ.
In order to account for the emergence of the unmarked vowel in those cases where harmony is blocked between the stem and an underspecified affix, I assumed that the scope of *S-IDENTσ is limited to the domain of the stem. It is noteworthy to consider stem forming affixes which begin with a vowel. For instance one affix which derives participial forms of positional verbs, the affix *–Vkb'al* exhibits systematic alternation of its first vowel.

(55) Participles of positional verbs

hay-akb'al-en	'I am stretched out'
k'eb'-ekb'al-en	'I am leaning'
tʃil-ikb'al-en	'I am lying down'
ʃol-okb'al-en	'I am kneeling'
kul-ukb'al-en	'I am sitting'

This occurrence of harmony in a derivational suffix is an effect of the ranking of S-IDENTμ above *S-IDENTσ. Only when the harmony constraint is vacuous, i.e. in case of an intervening moraic coda consonant, the candidate is chosen which satisfies the constraint on dissimilation.

(56) Evaluation of vowel harmony with a derivational vowel-initial suffix:

/tʃil+Vkb'al+en/	S-IDENTμ[b,h,l]	*S-IDENTσ[b]$_{stem}$
☞ a. tʃilikb'alen	*	*
b. tʃilukb'alen	*!*	
c. tʃilakb'alen	*!*	*

The other case of dissimilation can be observed with a second type of participle that can be formed from positional verbs. In this case the verb root is reduplicated and a morpheme of the form *–Vn* occurs between reduplicant and base, which dissimilates in height with the root vowel. See the examples in (57).

(57) Second participle of positionals

háay-*u*n-háay	'stretched out here and there'
k'éeb'-*u*n-k'éeb'	'leaning here and there'
tʃíil-*e*n-tʃíil	'lying here and there'

ʃóol-*e*n-ʃóol 'kneeling here and there'
kúul-*e*n-kúul 'seated here and there'

If the vowels *a* and *e* are regarded as low, whereas the others, i.e., *i*, *o*, and *u* count as nonlow, the appearance of *u* and *e* in the affix in the neighbourhood of the respective vowels can be analysed as height dissimilation affecting the feature [±low].The problem with these forms is that according to the analysis developed so far they should exhibit harmony, and not a second type of dissimilation.

Since this pattern is not crucial for the basic argumentation in this paper, and since an analysis of Yucatec Maya reduplication is beyond the scope of this paper, I will give only a brief sketch of a possible analysis.

The analysis relies on the observation that this type of dissimilation is found only with reduplication. In the account of McCarthy & Prince (1995, 1997), reduplication is a violation of the Integrity constraint on segments (34). All underlying segments of a stem are mapped into two representations on the surface instead of a one-to-one mapping. The limited occurence of height dissimilation in Yucatec Maya is covered by a highly ranked local conjunction (Smolensky 1993, 1995, Łubowicz 1998) of Integrity and the constraint responsible for dissimilation, i.e *S-IDENT[low].

(58) Local Conjunction: *S-IDENT[low]&INTEGRITY$_{seg}$; D = stem.
This local conjunction of two constraints is violated iff within the designated domain, i.e. the stem, both constraints are violated, *S-IDENT[low] as well as INTEGRITY$_{segment}$.

This means that the dissimilation constraint has to be satisfied whenever the integrity of underlying segments is violated by reduplication. The other choice would be to avoid reduplication. Since dissimilation does not occur in the reduplicant, the local conjunction has to rank below IO-IDENTITY and below any BR-Identity (base-reduplicant identity). This ranking implies that the dissimilating vowel is underspecified at least with regard to height. The alternating vowel surfaces as *u* as well as *e*, i.e. as back rounded as well as front unrounded. The change in backness is not directly triggered by the shape of the surrounding vowels, because these are back as well as front with *e*. From this I conclude that the alternating vowel is underlyingly specified as [+back], and IO-IDENT[bck] is ranked below the local conjunction. The change in backness and roundness in the surface form of the affix in the different environments is a repair strategy: There is no low back rounded vowel, since *o* patterns with the nonlow vowels. If the affix vowel has to be nonhigh in satisfaction of the local conjunction, it also has to be front and unrounded; if it has to be high it can surface with its underlying backness specification which automatically entails roundness, since there are no back unrounded vowels in Yucatec. Note in this respect that *a* is a front vowel according to its behaviour in backness dissimilation.

(59) Ranking:
IO-IDENT[hi,lo] >> *S-ID[low]&INTEGRITY$_{seg}$ >> IO-IDENT[bck] >> S-IDENT >> *S-IDENT

(60) Lexical entry for the 'participle of distribution': /high tone, -$V^{[+bck,+hi]}n$, Red /

This analysis is illustrated by the candidate evaluation in (59).

(61) Evaluation of height dissimilation in *tʃíil-en-tʃíil* 'lying here and there'

/tʃíil+V$^{[+bck,+hi]}$n+Red/	IO-IDENT [hi,lo]	*S-IDENT[low] &INTEGRITY$_{seg}$	IO-IDENT [bck]	S-IDENT	*S-IDENT [bck]
a. tʃíiluntʃíil		*!		*	
☞ b. tʃíilentʃíil			*	*	**
c. tʃíilontʃíil		*!		*	
d. tʃéeluntʃéel	*!*			*	
e. tʃíilintʃíil		*!	*		**
f. tʃíilantʃíil	*!		*	*	**

In tableau (61), the local conjunction rules out the most faithful candidate (a), because this candidate violates INTEGRITY$_{segment}$ by each stem segment which is repeated in the reduplicant, as well as it violates *S-IDENT[low], since all vowels of the form are [-low]. Both single constraint violations add up to violation of the local conjunction of both constraints. Candidate (b) avoids violation of the local conjunction by satisfying one of the two conjoints, i.e. *S-IDENT. Candidates (c, e) are out for the same reason as candidate (a). The remaining two suboptimal candidates are worse than (b), because both have changed underlying feature specifications. Candidate (d) has changed the value of [-low] of both underlying /i/'s to [+low], and candidate (f) has changed the underlying [+high] specification of the affix to [-high]. This violates high ranking IO-Identity.

Yucatec Maya displays some other environments where reduplication is explored as well to express grammatical information like plurality or repetition / habituality. In these cases, there is no affix intervening between base and reduplicant. I assume that in all these cases dissimilation of the reduplicant with respect to the base is blocked by the high ranking Input-Output faithfulness constraints and by high ranking faithfulness constraints on the base-reduplicant correspondence relation (see McCarthy & Prince 1995, 1997 on the issue of underapplication in reduplication).

This completes the analysis of Yucatec Maya vowel alternations.

3.6 Summary

I will finish section 3 with a summary of the Yucatec grammar provided in this paper. It was shown in section 3.1 that Input-Output faithfulness has to rank above the constraint on harmony, which ranks above markedness constraints. Together with the assumption of underspecification of alternating vowels, this describes morpheme-specific harmony. Section 3.2 gave evidence for the claim that the mora is the relevant category which stands in a correspondence relation with neighbouring elements of the same type. This is the reason why the locality requirement blocks harmony when a consonant cluster stands between two vowels which should otherwise harmonise. In 3.3, empirical evidence was given that harmony is not progressive per se, and directionality effects were explained by the ranking of INTEGRITY(F)Affix above S-IDENT and general INTEGRITY in the cases where affixes refused to trigger harmony. Regressivity of harmony in clitics finds an explanation in constraints on morphological expressivity (i.e., MORPHOLOGICAL TRANSPARENCY). General INTEGRITY has to be ranked below S-IDENT to derive any harmony effect at all. Section 3.4 showed that reranking of S-IDENT with regard to MAX-IO results in vowel elision. In order to avoid violations of S-IDENT, vowels can be skipped in fast speech, in violation of MAX-IO. The difference between fast and slow speech lies in the different rankings of constraints in both registers. In fast speech, constraints which facilitate pronunciation are promoted over IO-Faithfulness. The constraint on dissimilation was defined over the syllable as the relevant category for discorrespondence in section 3.5. Its scope was defined as holding only over the domain of the stem, whereas the harmony constraint has a larger scope, i.e. the Prosodic Word. Furthermore, S-IDENT ranks crucially above S-IDENT. This explains why no dissimilation of underspecified vowel-initial (derivational) suffixes is observed, but instead harmony applies with these. Another result of section 3.5 is that a phonological pattern can also be restricted to a morpheme by the means of Local Conjunction of constraints. Height dissimilation emerges due to underspecification of the relevent affix vowel as well as the conjunction of the respective constraints on dissimilation [*S-IDENT(lo)] and against reduplication (INTEGRITY$_{segment}$). The ranking (for slow speech) is given in (62).

(62) Yucatec Maya ranking:

MAX-IO, MT, INTEGRITY(F)Affix

IO-IDENT[hi,lo]

*S-IDENT[low]&INTEGRITY$_{seg}$

IO-IDENT[bck]

S-IDENTμ[b,h,l]PWd

*S-IDENTσ[bck]stem

*[+BACK], *[+HIGH]

INTEGRITY(F)

*[+LOW]

This grammar and minimal reranking of the assumed constraints for the fast speech register account for the emergence of all four phenomena displayed by Yucatec Maya vowel phonology, that is vowel harmony, disharmony, dissimilation, and vowel elision.

4 Comparison with other OT approaches to harmony

In the preceding sections, a correspondence approach to vowel harmony was developed and applied to vocalic alternations in Yucatec Maya. The question remains why one should prefer this account over other well-established theoretical devices to handle such data. This will be discussed in the following. I will not discuss shorthand constraints like HARMONY (Inkelas 1994), SPREAD[feature] (Kaun 1995), which certainly are meant only as place holders for more elaborated technical devices. Otherwise they would inflate the system of constraint families, and such an enrichment of theoretic tools should be avoided if possible. Within OT there are two main streams with regard to the analysis of vowel harmony: the Alignment approach (Kirchner 1993, Smolensky 1993, and many others) and the Positional Faithfulness approach (Beckman 1997, 1998).

4.1 Alignment

The Yucatec vowel harmony does not pose an empirical problem for the alignment approach to vowel harmony as developed by Kirchner (1993), Cole & Kisseberth (1994), Pulleyblank et al (1995), Ringen & Vago (1995), Padgett (1995), Pulleyblank (1996) and others. In this approach, it is assumed that certain constraints of the Alignment family (McCarthy & Prince 1993) demand that the edges of certain features coincide with the edges of other phonological or morphological categories like 'word' or 'stem'. The major problems of an alignment approach are of theoretical nature: There is no intrinsic ban against long distance consonantal feature assimilation. Goad (1996, 1997) presents an alignment analysis of consonantal place harmony in child language. In her conclusion, Goad addresses the question why long distance consonant harmony is not found in adult speech, but she has to leave this issue open.[18] The only possible explanation would be to assume a universal ranking for adult grammars of LOCALITY or NOGAP (Padgett 1995, Itô, Mester & Padgett 1995, Pulleyblank 1996) higher than ALIGNL/R(feature, P-Cat) ('the left/right edge of every feature span F coincides with the left/right edge of a phonological category P'). However, long distance phenomena among consonants almost always involve complete copying of all features of a segment in adult language. This lead Gafos (1998) to a convincing analysis in terms of reduplication for consonantal copying.

Under the assumptions made so far, dispensing with traditional planar segregation (i.e. different consonantal and vocalic tiers in the feature geometric sense), vowel harmony automatically skips consonants because it goes from mora to mora, while consonantal harmony cannot permeate through vowels, which by their vocalic nature do not bear consonantal features. An Identity relation can only be established between features that are already present. Consonantal features are not salient on vowels, so corresponding consonantal features in a CVCV string would violate the locality requirement. With such a theory of assimilation, it is not necessary to assume something like a "bottleneck effect" (Ní Chiosáin & Padgett 1997). Arguments against Ní Chiosáin & Padgett's account also come from the simple fact that not only place and roundness features but also height features participate in assimilatory long distance phenomena. Height harmonies are observed in several languages (see Goad 1993, Beckman 1997 and many others), and total harmonies are attested at least in Ainu (Dettmer 1989, Îto 1984), Mazahua (Spotts 1953), and Mayan. Even though rounding might be coarticulated on consonants, it is doubtful whether this is of any phonological relevance. For height features, it may be physically impossible to let the tongue remain in a certain position while articulating the intervening consonant (if it is not accidentally one which is articulated without tongue involvement, e.g., a labial or glottal stop). Another point is that the number of intervening consonants is relevant, as was shown above.

Another drawback of the Alignment analysis as well as of rule based solutions is the intrinsic directionality of assimilation which is inherent to them. Nondirectionality of assimilation seems to be the rule rather than the exception. Clements and Sezer (1982) have shown that Turkish vowel harmony is bidirectional, too. Another well known example is the bidirectionality of voicing assimilation as is observed in Dutch for example (see Grijzenhout & Krämer 1998).[19] A rule or constraint containing the direction of assimilation like $X \rightarrow [\alpha F]/\_Y[\alpha F]$ or

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[18] In fact Goad assumes the reason for this to lie outside of grammar.

[19] See also the discussion of the directionality issue in Baković (2000) and references cited there.

ALIGNLeft/Right(Feature, P/M-Cat) does not adequately cover such data, unless it has a mirror image counterpart. Therefore, Kirchner (1993) had to assume two constraints ALIGNRight(feature, word) and ALIGNLeft(feature, word) to cover the nondirectional nature of Turkish vowel harmony. Rule-based approaches to assimilation had to write additional unintuitive rules. If assimilation is seen as a transitive Identity relation among elements within the same representational string, the theoretical expenditure is reduced in two ways. First, there is no separate constraint needed for each direction of assimilation. Second, assimilation of consonants and vowel harmony can both be covered by constraints of the same family (Syntagmatic Identity), and not by two different types of constraints, i.e. Identity constraints for consonants on the one hand and Alignment constraints for vowels on the other hand.
Additional arguments against an Alignment analysis can be found in Beckman (1997). She proposes alternatively to capture vowel harmony solely by Positional Faithfulness and Markedness constraints. This approach has its own benefits and disadvantages as is discussed in the next subsection.

4.2 Positional Faithfulness

Beckman (1997) proposes to analyse vowel harmony as an effect of the interaction of Positional Faithfulness with Markedness. Positional Faithfulness guarantees that the underlying specification of a vowel in prominent position triggers harmony (for instance, the one in the first syllable of a word). Markedness militates against the realisation of feature specifications in other, non-prominent positions. On the one hand, the account is rather appealing since a) it implies a typology of vowel harmony, because harmony effects are directly related to the markedness hierarchy, and b) it describes harmony as an effect of the interaction of independently motivated constraints, without reliance to a specific harmony constraint.
On the other hand, this account alone cannot capture the consonantal blocking effect observed in Yucatec Maya. This would require a modification of Beckman's assumption on the structural organisation of features and the introduction of a (potentially rankable and violable) constraint on Locality of feature association. Nor can Beckman explain why vowel harmony stops at certain boundaries. She would have to assume that words are evaluated in isolation and not in whole utterances or phrases. Under this premise, however, phenomena which apply in larger domains, like that of the prosodic phrase, become problematic. Related problems come from the typological observation that in some languages clitics participate in vowel harmony (e.g. Turkish; see for instance Lewis 1967), while in others they do not (e.g. Yoruba, see Pulleyblank 1996: footnote 7). Another difficulty arises with the regressive harmony in clitic clusters in Yucatec Maya. The Positional Faithfulness account would predict that the clitic cluster acquires the feature specifications of the initial syllable of the stem, which is not the case. Thus, I conclude that Syntagmatic Correspondence as well as reference to featural Integrity are needed.

5 Conclusion

In this paper, I have given arguments for analyzing vocalic assimilation as correspondence between moras and syllables. Evidence for this theoretical assumption comes from several sources: The apparent nondirectionality of featural assimilation is a challenge for directional rule based or constraint based Alignment approaches. It can be expressed adequately by the

transitivity of featural Identity relations as provided by Correspondence Theory if these are extended to Syntagmatic Identity.
Correspondence intrinsically provides us with an explanation of locality effects like blocking of vowel harmony by coda consonants, because a rather abstract notion of Locality is incorporated into the definition of Correspondence already. There are no intermediate representations allowed between two corresponding elements in whatever dimension of correspondence. This only had to be spelled out more expressively. Future research has to show how transparency of neutral vowels (as is observed in Finnish, Hungarian, Wolof and many other harmony systems) can be handled in such a restrictive theory. Probably the locality condition has to be regarded as an independent rankable constraint, as was proposed for instance by Itô, Mester & Padgett (1995) with their NOGAP constraint.
In the understanding of phonological feature interaction developed here the notion of 'domain' plays two crucial roles: On the one hand, it is assumed that phonological feature interaction takes place on prosodic domains or – better – on categories, instead of exclusively relying on feature nodes. On the other hand, it is to be noted that (besides stress and syllabification) harmonising features group together words to utterances or phrases, they group together syllables or moras to words and they group segments into syllables. That is, besides obvious minimisation of articulatory effort, assimilation has an integrative domain identifying function. Besides this prosodic/syntactic grouping it is also important to maintain the identity of morphological atoms of which larger units are composed, therefore dissimilation and IO-Faithfulness are constrained to morphological domains. On the one hand, prosodic categories serve as the sites of feature interaction. On the other hand, Syntagmatic Identity, IO-Faithfulness and OCP constraints are limited to phonological and morphological domains. It might be noted that with the device of restricted constraint domains not only the preferred direction of harmony can be modelled adequately. Additionally, effects which were ascribed to different levels (i.e., dissimilation on the stem level vs. assimilation on the word level of derivation) or Base-Output Correspondence (Benua 1995, 1997, Kenstowicz 1996) can be explained by restricted constraint domains without reference to such powerful devices like levels or transderivational correspondence. To illustrate the latter: the blocking of leftward harmony in forms like *tʃuylaken* 'I might hang' (where the quality of *a* is an effect of harmony blocking) may also be explained by a stipulated Output-Output correspondence relation of this complex form with the simpler output form *tʃuylak* 's/he might hang'.
One side effect of the view of assimilation provided in this paper is that dissimilation or dissimilatory OCP effects can be described as the Markedness correlate to Syntagmatic Correspondence. As outlined above this has some advantage over other theories of the OCP available within OT so far, in that it is more restrictive.
A second side effect of the investigation made in this paper are arguments for archephonemic underspecification (Inkelas 1994, Inkelas, Orgun & Zoll 1997). As argued by Inkelas, alternating structure is taken to be underspecified, and nonalternating structure as specified in underlying forms due to Lexicon Optimization (Prince & Smolensky 1993). Without this premise, the morpheme-specific harmonies explored here would have to be explained by the assumption of different constraint rankings for individual morphemes, or by different rankings on different levels of evaluation. These questionable moves have been avoided in this analysis and the fully parallelist architecture of Optimality Theory has been maintained.

Appendix: Abbreviations in the glosses

CAUS	causative	PAST	past tense
D	derivational affix	PERF	perfective aspect
DEM	demonstrative	PL	plural
DET	determiner	POS	positional
FUT	future tense	PR	present tense
IMPF	imperfective aspect	Q	question marker
N	-*n* (see footnote 7)	SG	singular
NEG	negative	SUBJ	subjunctive aspect
NEGF	negative final affix	TERM	terminative affix
PASS	passive voice	TR	transitive (applicative)

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